Instructional Approach Drives New Physics Classroom Design at Forest Hills:

The Origins of my Remodeling the Physics Classroom, by John Crookston.

During the summers of 1999 and 2000, I participated in two National Science Foundation funded month-long professional development workshops at the University of Maryland and St. Albans School to learn a new way to teach physics called Modeling Instruction. I was very impressed with this interactive approach and have been using it in my classroom ever since. I was equally impressed with the design of the physics classroom at St Albans School and hoped that I could somehow recreate it to some degree in my own classroom at Forest Hills, PA. Over the years I learned how to make MI work in a traditionally designed classroom and laboratory, but I had always hoped I would someday get the opportunity to design a classroom/lab that is better suited for MI. That opportunity came about in 2013 when I was asked to help design my physics classroom for the new Forest Hills Junior-Senior High School.

First and foremost, I wanted the teaching approach I use (MI) to drive the placement of everything in my room. I tried to envision how I would use everything in the classroom to teach using Modeling and how it would function together to best deliver Modeling Instruction.

What is Modeling Instruction?

For seventeen years I have been teaching physics using Modeling Instruction (http://modeling.asu.edu), (http://modelinginstruction.org/). The teacher's role in modeling is to establish and nurture a learning community whose members engage in scientific discourse and function in many respects like the scientific community. With teacher guidance, the students design or help design controlled experiments and use computer-interfaced sensors and probes or student-made video clips to gather data that is subjected to graphical analysis or video motion analysis using either graphing calculators or computer software. The teacher facilitates student discourse about experimental results through the use of student-prepared white boards that serve as the springboard for student discussion and peer review during "board meetings". The discourse results in the construction of coherent knowledge (models) based on laboratory evidence.

Students then use the newly constructed models along with multiple representations (graphs, math models, written descriptions, and motion maps) and teacher-introduced tools or skills to solve problems and perform deployment activities. The same approach of teacher-facilitated student discourse through the use of student-prepared white boards is used when solving problems. In Modeling Instruction, students learn physics by actually doing it and discussing with each other how it makes sense in terms of student-developed, evidenced-based models.

Modeling Instruction in a Nutshell

- Through carefully guided discourse using student prepared whiteboards of experimental results, students construct shared models, using various representations, to describe the laboratory experiences with physical systems and processes.

    - Let the students do the talking

    - Ask, "How do you know that?"

    - Require diagrams and representations whenever possible

    - Reach agreement through sense-making and shared meaning

Designing the new physics classroom

I used an online classroom/lab planner and made several scale models of the physics classroom including tables, chairs, demo desk, cabinets, etc. I moved everything around to see what works best considering the transitions from sitting and listening to active labs, to small group white board preparation, to whole class board meetings in the round, to demonstrations and deployment activities. I thought about how the traffic should flow, for the learning to be the easiest. (See the two diagrams at the end of this article.)

Like the physics lab at St Albans, I decided to have a single flexible space for the physics classroom, with no built in furniture except around the periphery of the room. The rationale for this was that many different things can happen in a physics class, on widely differing scales, including the possibility of large-scale kinesthetic experiments, microcomputer based laboratory work, calculator work, lectures, demonstrations, board meetings, etc. A highly flexible open space, which can be reconfigured as needed, would be most useful for this. The design was influenced by the design for the Workshop Physics laboratory at Dickinson College, and the classroom designs of Steve Skinner, physics teacher at Millard West High School, Omaha, NE [and Larry Dukerich's modification for Modeling Instruction – JJ] and Robert A. Morse, retired physics teacher at St. Albans School in Washington, D.C.

Overhead beams

Bob Morse's concept of a flexible space is the ability to fasten anything anywhere. For this purpose, Bob designed an overhead pipe grid with no suspended ceiling with the intent to have a more open ceiling, allowing the advantage of a higher floor to ceiling spacing plus have the ability to hang lab equipment from the grid and do more creative lab setups. For my classroom, the pipe grid design was modified into a large square of overhead beams placed in roughly in the center of the room and a drop down ceiling will be installed that maximizes ceiling to floor space.

Floor pattern

To facilitate experiments and demonstrations with rolling carts, bowling balls, and large air cars, air pucks and hovercraft, a smooth floor will be installed, and a pattern of bolt holes will be put in the floor for kinesthetic experiments using carts that students sit on while other students push or pull the cart, similar to the design at Dickinson College and St. Albans (see attached diagram). The bolt holes have 5/8 inch threaded inserts, and are equipped with plugs when not in use. A painted pattern of a 4-meter diameter circle centered and superimposed on a 2 x 8-meter rectangle will be used to provide a reference for making measurements of videotaped experiments.

Student seating: individual student desks vs. tables for two vs. Museum Stools

Like Steve Skinner, I decided on adjustable height tables for two students with locking wheels. This makes it possible to easily move the tables from a side-by-side arrangement of 2 lab tables for lab work along the periphery to Steve's arrangement of 6 two-student tables facing the middle of the room on either side of a teaching computer in the middle of the room. (See attached diagrams). This puts the teacher more or less in the middle of the students and they need only pivot their head one way to see the computer screen projected or the other way to see the whiteboard space on the opposite wall. Looking straight, they see me at the computer. Each group of 12 students sits facing each other. (See both diagrams. Steve has lab groups of 4 students who use 2 computers. In modeling instruction, groups of 3 who use 1 computer work best. For modeling instruction, one would design the room such that the projection screen is on the opposite wall, in place of one whiteboard. That would free up the space where the projection screen originally was for two more lab stations.)

Additionally, a class set small portable Museum Stools that stack will be used as seating for whole-class white board discussions. The stools can be easily arranged in a circle for "board meetings" for the practice of what is called circle white boarding or white boarding in the round.

Circle White Boarding

The modeling approach emphasizes the process by which students construct knowledge and understanding and requires students to discuss "how they know what they know." The most effective use of whiteboards during board meetings is to encourage this discourse to enhance student learning. Learning to effectively use board meetings to engage students in questioning, predicting, analyzing, and presenting their understanding for others to examine (and reach agreement through shared meaning) is the central, most valuable, yet most challenging part of Modeling Instruction.

Oddly enough, the seating arrangement and configuration of the room does significantly impact how students interact during board meetings and ultimately determines the success of the activity in terms of student learning and understanding. In my current room, the students sit at two rows of fixed lab tables and their prepared white boards are Velcro-mounted high on the periphery walls behind each row. This arrangement provides good line of site for the students as they sit at the lab tables with their worksheets and groups from each table take turns standing at their board and presenting their work for discussion. I have experimented with smaller classes doing a board meeting in the round (circle white boarding) and have found that students are more comfortable, more focused and tend to interact better which translates into a more productive discussion and the desired outcomes compared to the arrangement dictated by the room. With the flexibility of the new classroom design, it will be possible for students to actually sit in a circle on the Museum Stools with their whiteboards sitting on the floor in front of them facing the center of the circle. The circle arrangement along with the "rules of the circle" should result in better student engagement and enhanced learning.

Modeling and White Boarding: What Works

- Interactive engagement
- Student discourse & articulation
- Cognitive scaffolding
- Multiple representational tools
- Consensus-based model building
- Explicit hierarchal organization of ideas and concepts into models